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ABSTRACT

Step-down analysis is a multivariate technique that examines dependent variables across groups by using a series of univariate "F" tests done in an a priori order. The first "F" test results are the same as a univariate "F" test examining the dependent variable. Each of the following "F" tests then uses the previously used dependent variables as covariates. The null hypothesis tested by this method is that there is no effect across groups when dependent variables are listed in a specific order. Because step-down uses covariates, as does analysis of covariance (ANCOVA) and multivariate analysis of covariance (MANCOVA), and is performed in a series of steps, somewhat like stepwise analysis, step-down is compared across these different methods. The comparisons show that step-down analysis does not have the same problems as ANCOVA, MANCOVA, and stepwise analysis. However, step-down has its own problems that are discussed in more detail. (Author/SLD)

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Step-down Analysis:

A Comparison with Covariance Corrections and Stepwise Analysis

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Abstract

Step-down analysis is a multivariate technique that examines dependent variables across groups by using a series of univariate F tests done in an a priori order. The first F test results are the same as a univariate F test examining that dependent variable. Each of the following F tests then use the previously used dependent variable(s) as covariates. The null hypothesis tested by this method is that there is no effect across groups when dependent variables are entered in a specific order. Because step-down uses covariates, as does analysis of covariance (ANCOVA) and multivariate analysis of covariance (MANCOVA), and is performed in a series of steps, somewhat like stepwise analysis, step-down is compared across these different methods. These comparisons show that step-down analysis does not have the same problems as ANCOVA, MANCOVA, and stepwise; however, step-down has its own problems that are discussed in more detail.

Step-down Analysis:

A Comparison with Covariance Corrections and Stepwise Analysis

Step-down analysis is a multivariate technique that uses a series of univariate F tests to examine the difference in means across groups within a single dependent variable and the difference in shared variance across dependent variables given an a priori ordering of these dependent variables. Before you do a step-down, you must have a reason for believing that the dependent variables that you are studying are ordered. This expectation should be based on theory or previous research (Stevens, 1996). Criterion variables known to be important should go first, and more dubious or complex variables later (Finn, 1974).

This concept is easier to understand by looking at an example of a study that has an a priori ordering. Two measurement specialists design the third edition of a hypothetical test, the ABC Reading Test: Third Edition (ABCRT-III). They give the ABCRT-III to three grades of children (first, second, and third). They also give the first edition (ABCRT-I) and the second edition (ABCRT-II) of this test to these same children. They want to know if the ABCRT-III provides any new information about reading achievement across grade levels than the two previous versions. Their step-down a priori ordering would be (a) the scores on the ABCRT-I, (b) the scores on the ABCRT-II, and (c) the scores on the ABCRT-III.

Using this a priori ordering, first run a univariate F test using just the first dependent variable (i.e., scores on the ABCRT-I). Next run another F test using just the second dependent variable (i.e., scores on the ABCRT-II) but using the first dependent variable (i.e., scores on the ABCRT-I) as a covariate. Run another F test using just the

third dependent variable (i.e., scores on the ABCRT-III) but using the first and second dependent variables (scores on the ABCRT-I and ABCRT-II) as covariates (Stevens, 1996). The Statistical Package for the Social Sciences (SPSS) commands to do step-down are presented in Table 1.

There are several reasons to use step-down instead of several univariate F tests or a Multivariate Analysis of Variance (MANOVA) (Koslwsky & Caspy, 1991; Stevens, 1996):

1. Step-down decreases probability of Type I error;
2. Step-down makes the F tests independent;
3. Step-down makes the researcher think about the analysis before running it; and
4. Step-down allows the researcher to look at dependent variables across groups in relationship with each other.

Another reason for a decrease in the experiment-wise Type I error rate is that, when doing step-down analysis, there is no reason to run an additional multivariate F test as well (Stevens, 1996).

Step-down analysis makes the researcher think about the analysis before running it. The order that the dependent variables are entered affects the outcome of the analysis. Because the analysis is theory-driven, there is no need to run a multivariate omnibus test. Also, when researchers have to think about the data before the analysis, frequently they also tend to think before the data collection (Tucker, 1991). It is this planning throughout the entire process that makes an experiment well designed.

Step-down allows researchers to look at dependent variables across groups in relationship with each other. Researchers can find out how much influence one

dependent variable has on the data derived from a second dependent variable. This is done by taking out the effects of the first dependent variable measure on the second dependent variable by using the first dependent variable as a covariate.

Comparing Step-down Analysis to ANCOVA and MANCOVA

Because step-down analysis uses each previous dependent variable as a covariate, this might lead one to consider that step-down analysis has the same problems as the analysis of covariance (ANCOVA) and the multivariate analysis of covariance (MANCOVA). In the following, you will find a brief description of ANCOVA and some of its problems. A complete refresher of this information is available from Loftin and Madison (1991) and Thompson (1992).

ANCOVA/ MANCOVA

ANCOVA is a univariate technique that attempts to statistically control for the variation caused by a given variable as opposed to controlling through research design (Hinkle, Wiersma, & Jurs, 1998). This is frequently done in cases where researchers find that their sample is in some way not representative of the population that they are attempting to test. An example of this would be two researchers wanting to find the difference in pre-test and post-test scores on the ABCRT-III following students' participation in an experimental reading program. These researchers might approach a school to request the participation of their students in this program; however, of the three classes asked in this school, only the teacher of the class in the lowest ability group agreed to let her students participate in this reading program. The classroom teacher whose students are in the highest ability group agreed to his students taking the pre-tests and the post-tests, thereby letting his classroom be the control classroom. Because the

researchers want to be able to generalize their results across all three of the classes, they might try to statistically control for ability. The researchers would use each child's ability level as a covariate while running an ANCOVA.

To discover why using ability levels as a covariate is problematic in this instance, the following five conditions required for correct ANCOVA usage must be considered:

1. The covariate (or covariates) should be an independent variable highly correlated with the dependent variable.

2. The covariate should be uncorrelated with the independent variable or variables.

3. With respect to the dependent variable, (a) the residualized dependent variable (Y*) is assumed to be normally distributed for each level of the independent variable, and (b) the variances of the residualized dependent variable (Y*) for each level of the independent variable are assumed to be equal.

4. The covariate and the dependent variable must have a linear relationship, at least in conventional ANCOVA analysis.

5. The regression slopes between the covariate and the dependent variable must be parallel for each independent variable group. (Loftin & Madison, 1991, p.134)

The first condition states, "the covariate should be an independent variable that is highly correlated with the dependent variable" (Loftin & Madison, 1991, p.134). In the example, the covariate is the independent variable of ability level and the dependent variable is the pre-test post-test difference scores on the ABCRT-III. It is true that ability level of the student should relate to the scores found on the ABCRT-III. This condition is met.

The second condition states, "the covariate should be uncorrelated with the independent variable or variables" (Loftin & Madison, 1991, p.134). The covariate here is still ability, and the dependent variable is the group identification (i.e., control or experimental). Because the selection of who is in the control group and who is in the experimental group was predetermined by which class the student attended (the high ability class or the low ability class), then the covariate and the independent variable are correlated. This condition is not met.

The third condition states, "with respect to the dependent variable, (a) the residualized dependent variable (Y*) is assumed to be normally distributed for each level of the independent variable, and (b) the variances of the residualized dependent variable (Y*) for each level of the independent variable are assumed to be equal" (Loftin & Madison, 1991, p. 134). For this example, this statement states that, with respect to the pre-test/post-test difference scores on the ABCRT-III after taking out the variance accounted for by ability level, (a) the scores are still normally distributed and (b) the variances of the scores are still equal for both the control group and the experimental group. Without knowing if the original pre-test post-test difference scores on the ABCRT-III were normally distributed (and of equal variance across groups), and without knowing if ability levels were normally distributed (and of equal variance across groups), then there is no way of knowing if this condition is met or not.

The fourth condition states, "The covariate and the dependent variable must have a linear relationship, at least in conventional ANCOVA analysis" (Loftin & Madison, 1991, p. 134). Again, the covariate here is ability level and the dependent variable is pre-test/post-test difference scores on the ABCRT-III. It may not be true that, as ability

linearly increases, so should the pre-test post-test difference scores on the ABCRT-III, and as ability linearly decreases, so should the test scores. It is possible that the difference scores increase and decrease as ability increases or decreases, however, if this is true, how would one know if the increase/decrease is due to the group membership or the ability level? This is especially true here, where group membership is determined by ability level. It is unknown if this condition is met.

The fifth condition states, "The regression slopes between the covariate and the dependent variable must be parallel for each independent variable group" (Loftin & Madison, 1991, p. 134). This is also called the homogeneity of regression assumption (Thompson, 1992). This means that when the pre-test and post-test scores on the ABCRT-III (Y Axis) are graphed across ability levels (X axis) twice (once for the experimental group and once for the control group), these two regression lines should have the same slopes. To see an example of this, see Figure 1. This assumption will be met only if the test scores for the children with lower ability level increase at the same rate as the scores for the children with higher ability level. Given the nature of intellectual ability, it may not be wise to assume that that the children in this example will increase their scores at the same rate. It is likely that the children with high ability will learn faster than children with low ability. This condition is not met.

The above conditions apply to Multivariate Analysis of Covariance (MANCOVA) as well. However the first and fourth condition for ANCOVA combine to form the following condition for MANCOVA, "there is a significant relationship between the dependent variables and the covariates" (Stevens, 1996, 330). And the fifth condition becomes, "the homogeneity of the regression hyper-planes is satisfied" (Stevens, 1996, p.

330). The previous example can be easily modified by adding another dependent variable and evaluate the analysis based on the MANCOVA conditions.

Step-down Versus ANCOVA

Now examine these same conditions across a step-down analysis that uses dependent variables scores as covariates. If all of the above conditions are satisfied for step-down analyses, then using dependent variable scores as a covariate should not be problematic. The step-down example that we are going to use is similar to the ANCOVA example that we used above. This time the researcher wants to look at two dependent variables: scores on the ABCRT-III Pre-test and scores on the ABCRT-III Post-test. These scores will be considered across two randomly assigned groups: the control group and the experimental group. Ability level is not considered in this experiment because the groups are randomly assigned. The a priori ordering would be that the F test for the ABCRT-III Pre-test across the groups would be run first, and then the F test for ABCRT-III Post-test across the groups using the ABCRT-III Pre-test as a covariate would be run next. Step-down analysis is a multivariate analysis and not a univariate analysis; so the conditions for MANCOVA should be used.

The first condition states, "there is a significant relationship between the dependent variables and the covariates" (Stevens, 1996, p. 330). Remember, in step-down analysis the dependent variables are the covariates. So, the covariate for the second F test would be the ABCRT-III pre-test scores. The ABCRT-III pre-test scores and the ABCRT-III post-test should be related. This condition is then met.

The second condition states, "the covariate should be uncorrelated with the independent variable or variables" (Loftin & Madison, 1991, p.134). The covariate for

the second F test is still the ABCRT-III pre-test scores, and the independent variable is group membership. Because group members were randomly assigned, there should be no correlation between the ABCRT-III pre-test scores and group membership. This condition is met.

The third condition states, "with respect to the dependent variable (a) the residualized dependent variable (Y*) is assumed to be normally distributed for each level of the independent variable, and (b) the variances of the residualized dependent variable (Y*) for each level of the independent variable are assumed to be equal" (Loftin, & Madison, 1991, p. 134). For this example, this means the ABCRT-III post-test scores after taking out the variance accounted for by the ABCRT-III pre-test scores (a) are assumed to be normally distributed and (b) have equal variances across the experimental group and the control group. If we assume that the ABCRT-III post-test scores are normally distributed with equal variances across groups, then we are likely to assume that the ABCRT-III pre-test scores are also equally distributed with equal variances across groups. If both are normally distributed with equal variances across groups, then this condition can be considered met (Loftin, & Madison, 1991).

The fourth condition states, "the homogeneity of the regression hyper-planes is satisfied" (Stevens, 1996, p. 356). In this example, there was only one dependent variable that was analyzed using a covariate, and only one covariate, so the graph can still be done with two dimensions and doesn't invoke hyper-planes. This condition states that when we do two graphs of the ABCRT-III scores for the post-test scores (Y axis) across ABCRT-III post-test scores (X axis) the slope should be the same on both the control

group graph and the experimental group graph. To see an example of this, see Figure 2. Since the groups were randomly assigned, this should be true. This condition is met.

These conditions can be re-examined for every step-down analysis, and if the analysis is done correctly all of the conditions should be met every time. Since these conditions are met, then using a covariate in step-down analysis is not problematic. In fact, when the covariates are used correctly (i.e., all of the conditions are met) then systematic bias is eliminated and error variance is reduced (Stevens, 1996). This is how step-down makes the F tests independent and decreases the probability of Type I error.

Comparing Step-down to Stepwise

Stepwise

Stepwise analysis can be done for both univariate techniques (i.e., regression) and multivariate techniques (i.e., descriptive discriminant analysis). For either technique, stepwise is incremental in nature. In regression, the best predictor is selected first based on the shared variance of the predictor variable and the dependent variable. The second-best predictor is selected after the shared variance of the first predictor is removed. The second-best predictor in stepwise is the predictor that has the most additionally relevant variance after the variance from the first predictor is removed. The next steps are performed in a similar manner (Glass, & Hopkins, 1984).

The purpose of stepwise analysis is to select the best subset of variables from the larger set of predictors, usually assuming that the selected variables are in some way better than the unselected variables. Stepwise usually does not successfully do this, and in fact is problematic in several ways (Thompson, 1995). For a more thorough

explanation of the problems in stepwise, read Thompson (1995). Three main problems with stepwise that he describes are:

1. Stepwise calculations use the wrong degrees of freedom;
2. Stepwise doesn't identify the best set of predictors; and
3. The results in stepwise tend not to replicate.

Because step-down analysis removes the variance accounted for by the previous step, it is easy to confuse the problems in stepwise analysis as also occurring in step-down analysis. As you will see in the following two examples (one using a stepwise regression analysis and one using a step-down analysis), this is not necessarily true.

For the first example, the researchers are interested in looking at how gender, age, and participation in a particular driver's education program affect people's driving. One hundred participants of various ages and gender are randomly placed in 1 of 2 classrooms. One teacher uses class reading and hands-on experience to teach driver's education while another teacher uses the class as a study period. The researchers calculated the number of citations that each person received after finishing the class over the next four years. They hypothesized based on past research that the age of the students would impact the number of citations the most, their placement in a driver's education class would impact the next most, and their gender would have the least impact.

They enter each student's information into a stepwise regression equation to predict the number of citations the students received. The stepwise regression equation took into account all three predictor variables. The results indicated that the age of the student accounted for most of the variance in the number of citations and the gender

accounted for the next most variance (after removing the variance from the age), and class participation accounted for no variance.

Problem one states that the degrees of freedom used for the calculations in stepwise analysis are wrong (Thompson, 1995). If this were a regular regression equation, the total degrees of freedom would be N-1 (in this case, 99). The degrees of freedom explained would be the number of predictor variables (in this case, three), and the degrees of freedom error would be N-1- number of predictor variables (in this case, 96).

The researchers didn't use a regular regression equation; they used a stepwise equation. For this example stepwise only entered two predictors when determining the degrees of freedom. However, because all of the predictors were used when performing the stepwise analysis, then all of the predictors should be counted in the degrees of freedom (Thompson, 1995). This means that the total degrees of freedom is still 99, the degrees of freedom explained is now two, and the degrees of freedom error is now 97. Using these wrong degrees of freedom makes the F test statistics appear more statistically significant than they really are.

Problem two states that stepwise doesn't identify the best set of predictors (Thompson, 1995). Because the decision of which predictor to enter next is determined by which predictor was entered before it, stepwise is very situation-specific (Thompson, 1995). If the researchers had not chosen to look gender, it is likely that the ordering would have been different. As it stands here, stepwise analysis finds that there is no value in looking at class participation. In fact, classes participation might predict the number of citations received by the students more than the gender did. It may have been

that when the variance accounted for by age was removed, the overlapping variance accounted for by age and class participation jointly was removed as well.

Problem three states that the results given tend to not be replicable (Thompson, 1995). Given that stepwise analysis tends to capitalize on sampling error, then it is likely that the results found in one sample will not generalize when the same analysis is run on a different sample (Thompson, 1995). For our example, because the gender group did account for some of the variance, then class participation was not regarded as important. This may have been a result of sampling error. Given that their analysis did not find what the researchers hypothesized they would find based on previous research, it is even more likely that the sample is not replicable. This same finding might not be confirmed in other samples and the stepwise ordering would be different.

Step-down Versus Stepwise

Hypothetically, a different set of researchers wanted to do a similar experiment, but they used step-down instead. The researchers randomly placed the 100 teenagers in one of four classes (combined class, drive class, book class, and control class). They calculated the number of citations that each person received after finishing the class over the next four years. These citations were broken down into four categories: major accidents, major traffic violations, minor accidents, and minor traffic violations. The number of traffic citations in each category constituted the dependent variables (four dependent variables). They set up their step-down order based on their hypothesis that minor traffic violations led to minor accidents, minor accidents led to major traffic violations, and major traffic violations led to major accidents.

First, a univariate F test was run on the number of minor traffic violation citations for each class and statistical significance was found. Second, a univariate F test on the number of minor accidents was run (using the number of minor traffic violation citations as a covariate), and statistical significant was found. Third, a univariate F test was run on the number of major traffic violation citations (using the number of minor traffic violations and minor accidents citations as covariates), and statistical significant was not found. Last, a univariate F test was run on the number of major accident citations (using the control, drive, and book class' final scores as covariates) and statistical significance was not found.

For this example, like the stepwise example, only two of the variables were considered useful. However, unlike the stepwise example, these two were entered based on a theoretical framework. Also unlike the stepwise example, the variables used were dependent variables and not independent predictor variables.

The first stepwise problem states that the degrees of freedom used for the calculations in stepwise analysis are wrong. This does not happen in step-down. Each analysis is performed separately calculating the same degrees of freedom as would be normally calculated for an ANCOVA. Every variable used in every calculation is accounted for in the degrees of freedom. So, for our example, every dependent variable (number of traffic citations) was analyzed across every grouping variable (class membership). For every analysis, all of the variables are accounted for in the degrees of freedom. For an example of how this looks in a summary table, see Table 2.

The second and third problems with stepwise are that it doesn't identify the best set of predictors, and results tend to not be replicable. These problems are solved by

step-down (Thompson, 1995). Because the set of variables is entered according to theory, it is more likely that the results are replicable and in the best order. Along with this is that, given that the order is influenced by theory and not influenced by data, sampling error is less likely to influence the final results. Also true is that the effect for every dependent variable is calculated, not just those that are selected by the computer. However, these problems do appear in step-down when the research is designed on a weak theoretical basis. Also, these problems will occur if researchers choose to run several sets of step-down (changing the order in each one) until they find one that has "good enough" statistical significance. If the researchers do this, then the data are influencing interpretation instead of theory and the point of doing a step-down analysis is lost.

Thus, step-down analysis and stepwise analysis do not evaluate the same things. Stepwise asks the question, "How much does a predictor add to predicting the dependent variable above and beyond the previous predictors in the regression equation" (Stevens, 1996, p. 351) whereas step-down asks the question, "How much does a given dependent variable add to discriminating the groups, above and beyond the previous dependent variables for a given a priori ordering" (Stevens, 1996, p. 351). The differences in these two questions is what makes stepwise problematic and step-down preferred.

Problems with Step-down

Just because step-down doesn't have the same problems as ANCOVA and stepwise, this does not mean that it completely problem-free. However, many of the problems associated with step-down have to do with incorrect a priori ordering. The incorrect ordering could be due to problems with theory or problems in the researcher's

understanding of step-down procedures. The main problems are as follows (Finn, 1974; Koslwsky & Caspy, 1991):

1. When no order is appropriate or the wrong order is analyzed, the value of the results is questionable. The more wrong the ordering, the further that power decreases.
2. If previous correlated dependent variables are entered in the wrong order, then the following dependent variables will not show statistical significance.
3. Replicability can be a problem if the researchers do not have a good theory.
4. Sample size effects statistical significance.

Problem one states that when no order is appropriate, then the value of step-down results is questionable (Finn, 1974). This is because the hypothesis tested by step-down is that there is no effect across groups when dependent variables are entered in a specific, a priori order (Finn, 1974). If there is no a priori order, then the hypothesis becomes unknown, power decreases dramatically, and the results don't mean anything.

Problem two states that if previous correlated dependent variables are entered in the wrong order, then the following dependent variables will not show statistical significance (Koslwsky & Caspy, 1991). This is because the following step-down analysis removes the variance of the prior dependent variable across the groups. If this variance is shared between the prior and following dependent variables (i.e., the dependent variables are correlated) then this process will remove some of the variance accounted for by the following dependent variables as well. Doing this may cause the researchers to incorrectly assume that the following dependent variables contribute nothing to the total. This is especially true when the entry order is incorrect. Remember,

in most step-down cases, the researchers are interested in correlated dependent variables. In these instances, the researchers want to know what information the following dependent variables provide that the prior ones do not. If the order is incorrect, then the usefulness of the results is questionable.

Problem three states that replicability can be a problem if the researchers do not have a good theory (Koslwsky & Caspy, 1991). This is especially true if the ordering is wrong or if the researchers ignore the theory. If the researchers run several step-down analyses, changing the order in each one, and then choose the one that they prefer, then the sample data are deciding the results and not the theory. Because sample data frequently misrepresent the population data (i.e., sampling error), letting the data run the analysis might result in replicability problems. It is the very fact that step-down uses theory to run the analysis that makes it preferable to stepwise. Once the theory is removed, then replicability becomes an important issue.

Problem four states that sample size affects statistical significance. Remember that at some sample size (given that there is a non-zero effect size) statistical significance always will be found (Keiffer & Thompson, 1999). This is true with step-down as well. When deciding on the value of the results, it is important to keep in mind the effect size, sample size, and the statistical significance. Without examining all three, the usefulness of the results is questionable.

Summary

The problems frequently associated with ANCOVA, MANCOVA, and stepwise do not generally apply to step-down. However, as is noted, step-down does have its own problems to keep in mind. If a researcher keeps in mind the differences between the

techniques discussed and the positives and negatives to using step-down, then step-down can be a very powerful method for analyzing some data sets. It is not appropriate for every type of analysis and should only be used with those data sets that have dependent variables arranged in some meaningful order. It is the knowledge of this given order that gives step-down more power than many other methods. However, when this knowledge is incorrect, making the order incorrect, then step-down's power decreases dramatically

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Table 1

SPSS Syntax to Run Step-down Analysis

```
TITLE 'STEP-DOWN ANALYSIS'.
SET BLANKS=SYSMIS UNDEFINED=WARN PRINTBACK=LISTING.
DATA LIST FILE='A:\STEP-DOWN.TXT' FIXED RECORDS=1/
  CLASS 1-1 V1ABC 3-5 V2ABC 7-9 V3ABC 11-13.

LIST.

MANOVA V1ABC TO V3ABC BY CLASS(1,3)
  PRINT CELLINFO(MEANS) SIGNIF(STEP-DOWN).
```

Note. From Applied Multivariate Statistics of the Social Sciences: Third Edition (p. 356), by J. Stevens, 1996, Mahway, NJ: Lawrence Erlbaum Associates, Inc. Copyright 1996 by the Lawrence Erlbaum Associates, Inc. Adapted without permission.

Table 2.

Example Summary Table for Step-down Analysis

Source	SS	df	MS
$Between_{1st}$	SS_B	(k-1)	$SS_B/(k-1)$
$Within_{1st}$	SS_W	(n-k-1)	SS_W
$Total_{1st}$	SS_T	(N-1)	$SS_T/(n-1)$
$Covariate_{2nd}$	SS_{cov}	(1)	$SS_{cov}/(1)$
$Between_{2nd}$	SS_B	(k-1)	$SS_B/(k-1)$
$Within_{2nd}$	SS_W	(df_B-i-1)	$SS_W/(df_B-i-1)$
$Total_{2nd}$	SS_T	(N-1)	$SS_W/(n-1)$
$Covariate_{1st}$	SS_{cov}	(1)	$SS_{cov}/(1)$
$Covariate_{2nd}$	SS_{cov}	(1)	$SS_{cov}/(1)$
$Between_{3rd}$	SS_B	(k-1)	$SS_B/(k-1)$
$Within_{3rd}$	SS_W	(df_B-i-1)	$SS_W/(df_B-i-1)$
$Total_{3rd}$	SS_T	(N-1)	$SS_T/(n-1)$
$Covariate_{1st}$	SS_{cov}	(1)	$SS_{cov}/(1)$
$Covariate_{2nd}$	SS_{cov}	(1)	$SS_{cov}/(1)$
$Covariate_{3rd}$	SS_{cov}	(1)	$SS_{cov}/(1)$
$Between_{4th}$	SS_B	(k-1)	$SS_B/(k-1)$
$Within_{4th}$	SS_W	(df_B-i-1)	$SS_W/(df_B-i-1)$
$Total_{4th}$	SS_T	(N-1)	$SS_T/(n-1)$

Note. N = total number of people in the sample; k = total number of cells; ' = adjusted; i = order the variable is entered

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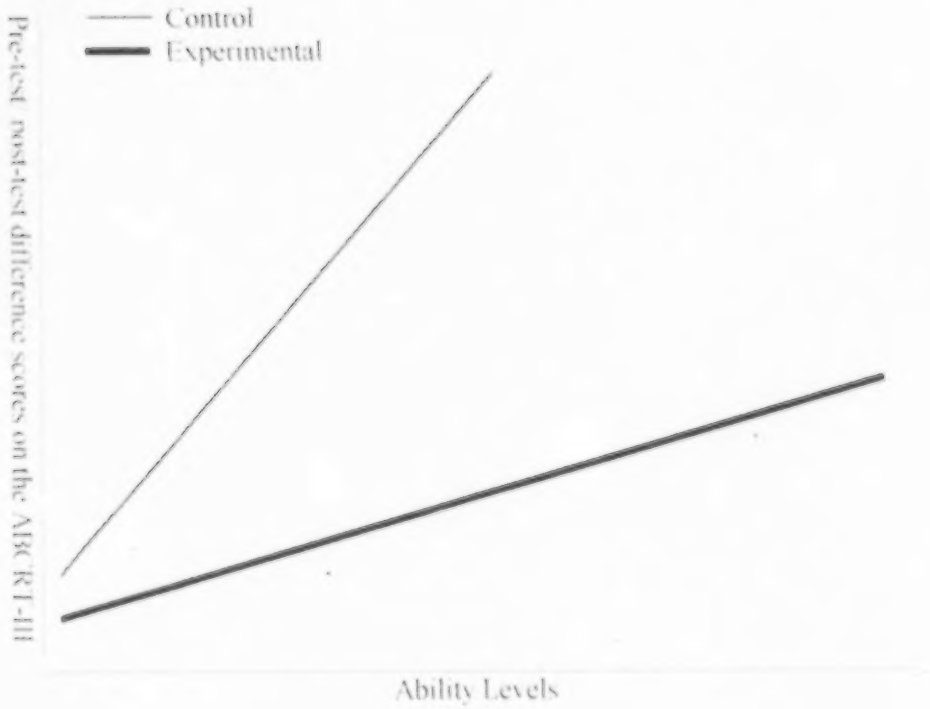
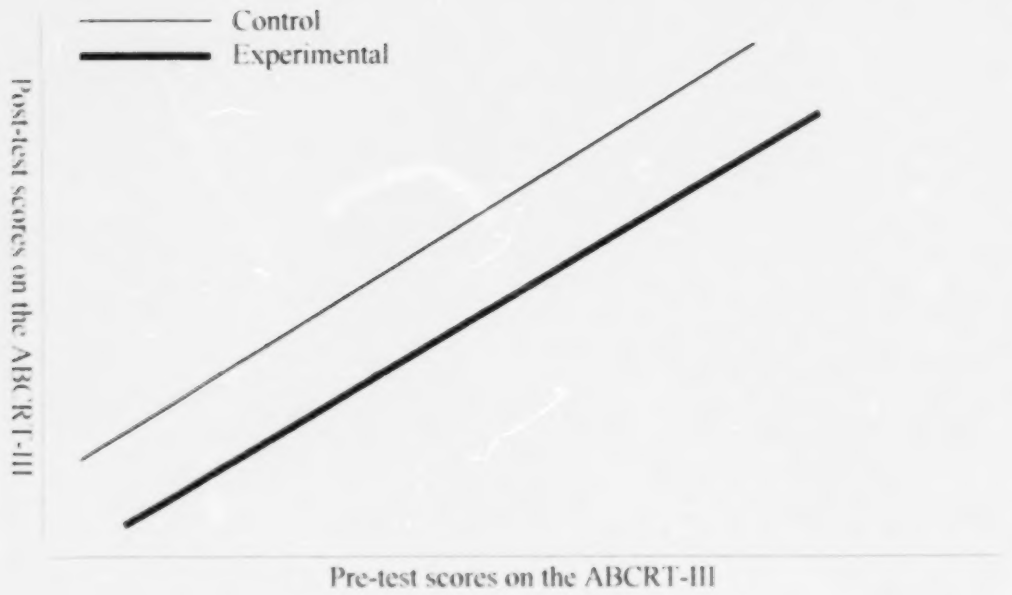
Figure Caption

Figure 1. Graphing homogeneity of regression in ANCOVA.

Figure 2. Graphing homogeneity of regression in Step-down.


Control
Experimental
Pre-test post-test difference scores on the ABCRE-III
Ability Levels



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